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LARGE SCALE METEOROLOGICAL INFLUENCE DURING THE GEYSERS 1979 FIELD EXPERIMENT

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ABSTRACT

A series of meteorological field measurements conducted during July 1979 near Cobb Mountain in Northern California reveals evidence of several scales of atmospheric circulation consistent with the climatic pattern of the area. The scales of influence are reflected in the structure of wind and temperature in vertically stratified layers at a given observation site. Large scale synoptic gradient flow dominates the wind field above about twice the height of the topographic ridge. Below that there is a mixture of effects with evidence of a diurnal sea breeze influence and a sublayer of katabatic winds.

The July observations demonstrate that weak migratory circulations in the large scale synoptic meteorological pattern have a significant influence on the day-to-day gradient winds and must be accounted for in planning meteorological programs including tracer experiments.

I. SYNOPTIC METEOROLOGY DISCUSSION

Although a preliminary survey of the five experimental nights of the ASCOT field program at Anderson Creek Valley, California indicates a basic similarity in the drainage wind structure from one night to another, the detailed analysis of wind structure reflects significant differences. One potential cause of the difference is the variation in free stream winds at and above the ridge top due to an evolving synoptic scale pressure pattern. Although the mean pattern of high pressure over the eastern Pacific Ocean and low pressure over the southwestern U.S. persisted throughout the period, a series of weak migratory circulation systems accounted for a continually changing gradient wind over the experimental area. This gradient wind exerted a major influence on the observed winds in the more exposed areas of the ridge-valley complex.

The early part of the experimental period, July 18th, 19th and 20th, was dominated by a particularly well developed thermal low pressure area covering the southwestern U.S. Large scale winds were light and temperatures were abnormally high. During the experiment night of July 20-21 a cold front moved through the area from the north and produced thunderstorms in the northern California coastal mountains. A weak high pressure ridge moved into the area after the front passed. During the experiment night of July 22-23 the ridge weakened leaving a weak cyclonic circulation in northern California at lower tropospheric altitudes. Pressure gradients weakened further on July 24-25. Low level divergence developed in central California during the night with convergence into three weak low pressure centers in eastern Oregon, New Mexico, and in the Pacific about 300 miles offshore from southern California. The Pacific low drifted onshore and was present in the Geysers area during the night of July 26-27. Except for the frontal passage of July 20-21, none of the circulation features described here was vigorous enough to produce clouds or weather events. The gradient winds did vary in a continually evolving pattern due to the migratory features in the pressure field. The altitude level at which gradient flow exerts an optimum influence on local topographic wind patterns is the effective ridge height where the terrain is most exposed to the outer flow. Lee side effects of sheltering, separation, vertical streamline confluence and waves will be initiated by interactions at ridge level. The topography in the Anderson Creek Valley area reaches 975 to 1430 m MSL. The 850 mb level is representative of these altitudes. For purposes of interpretation of interactions of external wind fields with locally generated drainage winds, a set of 850 mb contour charts and streamlines is provided in Figures 1 through 8.

II. MESOSCALE INFLUENCE

The confluence of low altitude air into a summer time thermal low pressure area in the Great Basin represents a characteristic monsoon type of circulation depicted in Figure 9. This pattern is distinctly seasonal but does not vary diurnally. However, superposed sea breeze effects do produce a diurnal pattern of winds close to ground level. Fosberg and Schroeder (1966) document the penetration of marine air into the Middletown, California area. The marine air is significantly modified during its overland travel through the coastal mountains. At Middletown, high temperatures and low humidity are more characteristic of continental air. Wind hodographs derived from 45 summer days reflect a diurnal wind pattern with southwesterly flow peaking in mid-afternoon and a brief period of northeasterly winds after sunrise that Fosberg and Schroeder suggest is due to a land breeze.

The properties of the sea breeze depend somewhat on synoptic features. Fosberg and Schroeder suggest that when the Pacific high pressure cell extends onshore into the Pacific northwest the seabreeze is slowly moving and shallow with a well defined sea breeze front that does not extend far inland. When a weak trough exists over the coastal area the sea breeze is deeper and moves more rapidly and further inland. However, the boundary is more poorly defined than the warmer, shallow case.

Meteorological measurements made close to ground level often reflect a combinatin of phenomena that may complicate their interpreation. Especially in complex terrain, measurements to be related to the large scale pressure gradient should be collected above the localized influence of mountain-valley winds or obstacle flows. During the July 1979 Geysers field program LASL operated a dual-theodolite tracked pilot balloon wind profile system equipped with a portable temperature sonde. These measurements extended to 2 to 3 km above local terrain. Figures 10 through 13 represent time-height cross sections of wind direction from the surface to the upper extent of the soundings. The wind directions above twice the ridge height generally agree with the 850 mb streamlines derived from the NWS limited fine mesh analysis. The 850 mb level is the nearest standard analysis level to the ridge top free stream wind and is located at about 1 km above the base of the soundings.

Below about twice the ridge height the winds appear to be affected by local influences. This lower layer has several subregions defined by characteristics of the wind direction cross section. A shallow and generally persistent layer of west to northwest wind is identified with the locally driven katabatic wind. In the transition layer from 200 m to 1 km above ground the wind direction exhibits one or two excursions during the course of the night from westerly through northerly. The largest meanders result in easterly winds for 1 to 2 hours at a time. Above the transition layer the wind directions are steady and agree with the synoptic scale streamlines.

The temperature field in the lowest 1400 m is presented in time-height cross sections (Figs. 14-17) that show several consistencies and some major differences from night to night. All the figures show the development of a shallow stable layer due to nocturnal cooling at ground level after sunset. A zone of warm air persists between 200 m and 600 m (ridge top) until about 0300 PST. The data are insufficient to establish a rigorous relationship but there appears to be a connection between the maximum cooling aloft and a pre-dawn surge of easterly winds. Above 1 km the temperatures generally decrease with elevation and exhibit small but observable oscillations in time.

III. SUMMARY

At the first level of detail, the summer large scale meteorology of the northern California coastal mountains is governed by a monsoon type of flow between the Pacific high pressure cell and a thermal low in the Great Basin of the western U.S.. However, weak migratory circulation systems produce day to day variations of wind direction above the level of local influence. Sea breeze and local terrain dominated winds are superposed on the varying synoptic pattern and control the winds in the lowest 1-2 km above sea level.

A series of soundings that extend above 2 km near the site of a boundary layer meteorological experiment provides a link between the local domains of wind flow and the free stream wind. During the July 1979 Geysers field experiments the LASL pilot balloon soundings with minisonde temperatures fulfilled this interpretive link.

REFERENCE

Fosberg, M. A. and Schroeder, M. J., "Marine Air Penetration in Central California", J. Appl. Meteorol., 5, 573-589, 1966.

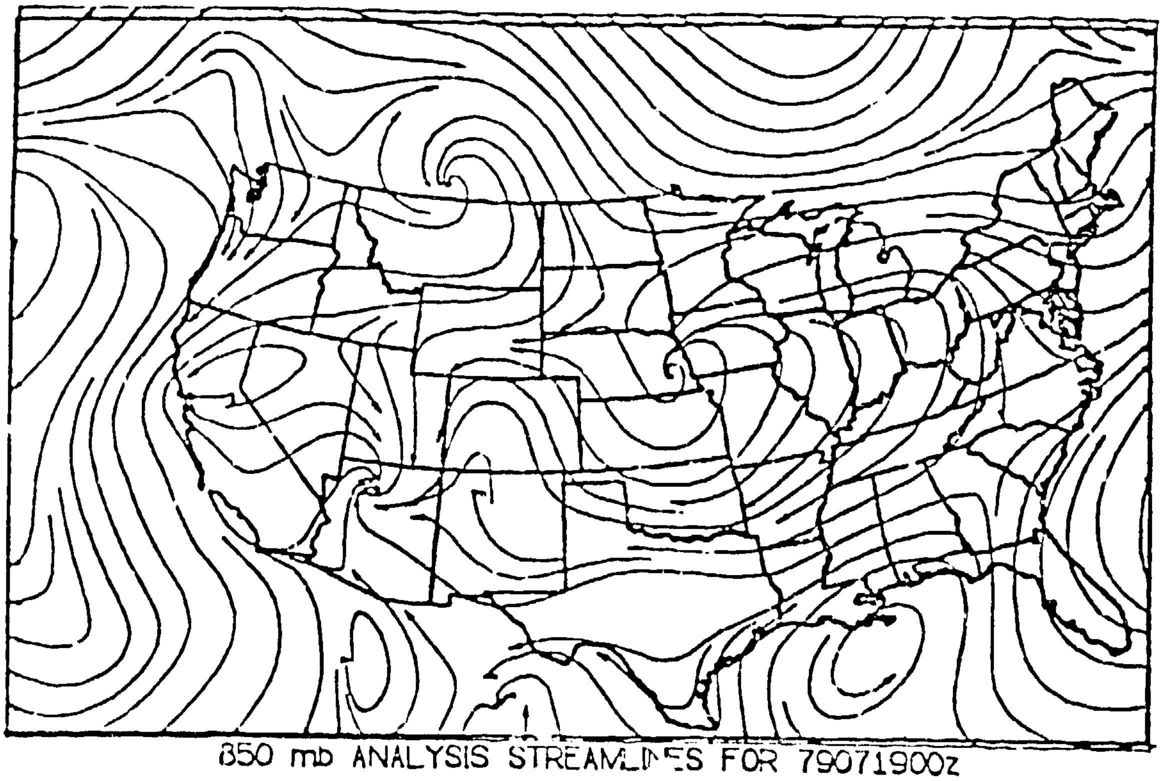
850 mb ANALYSIS STREAMLINES FOR 79071900z

Fig. #1

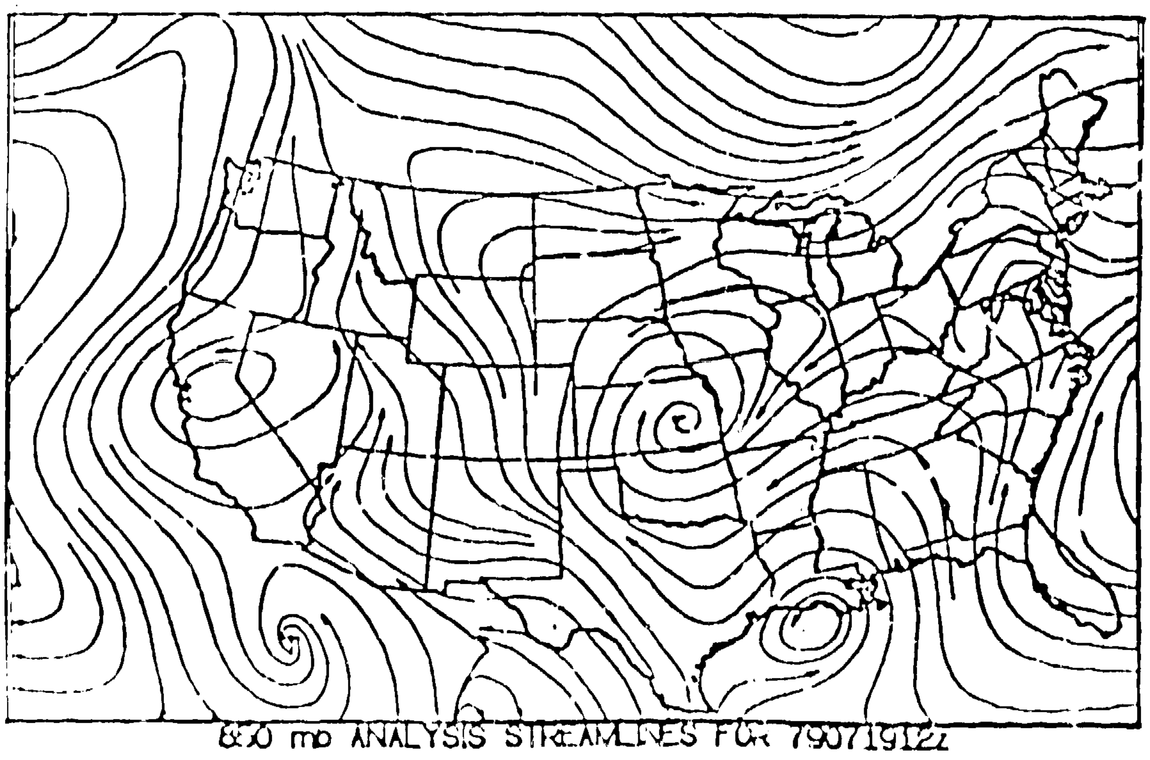
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Fig. #2

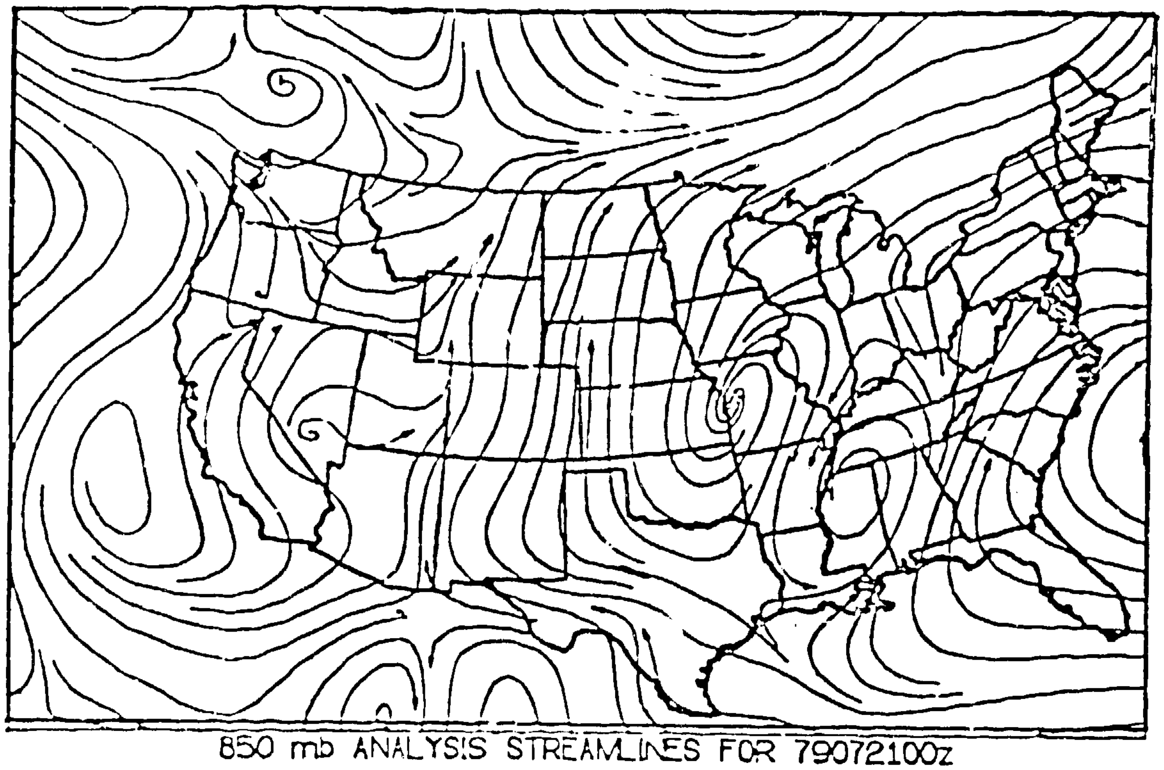
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Fig. #3

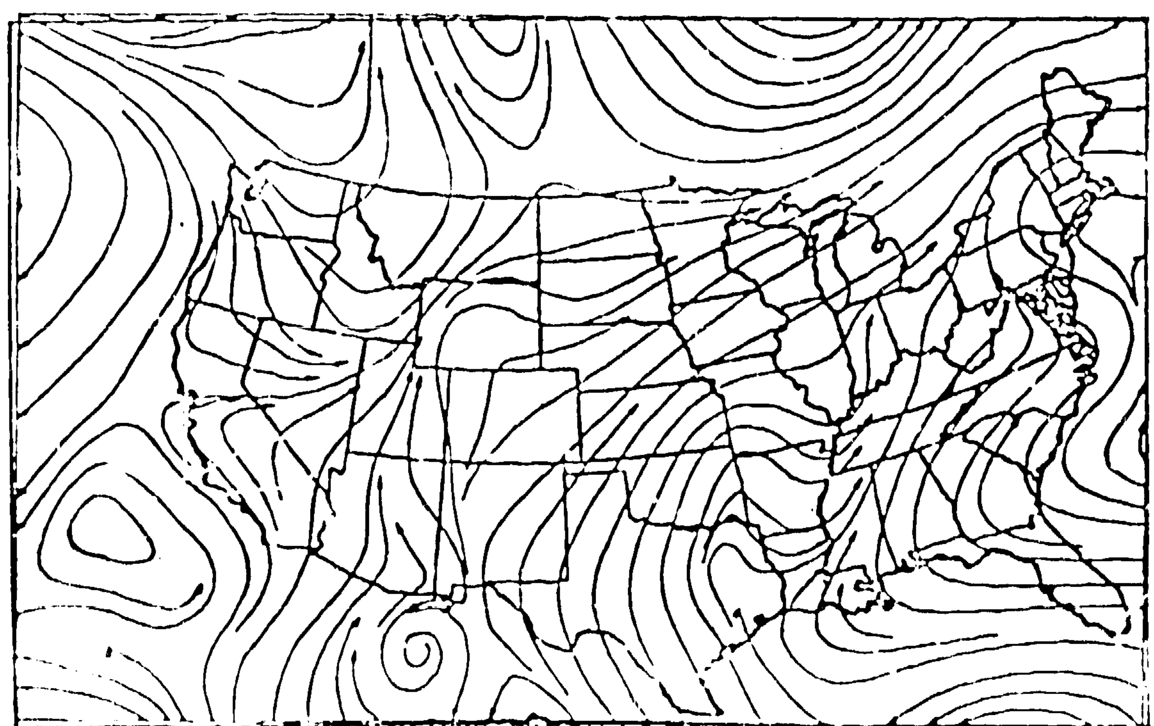
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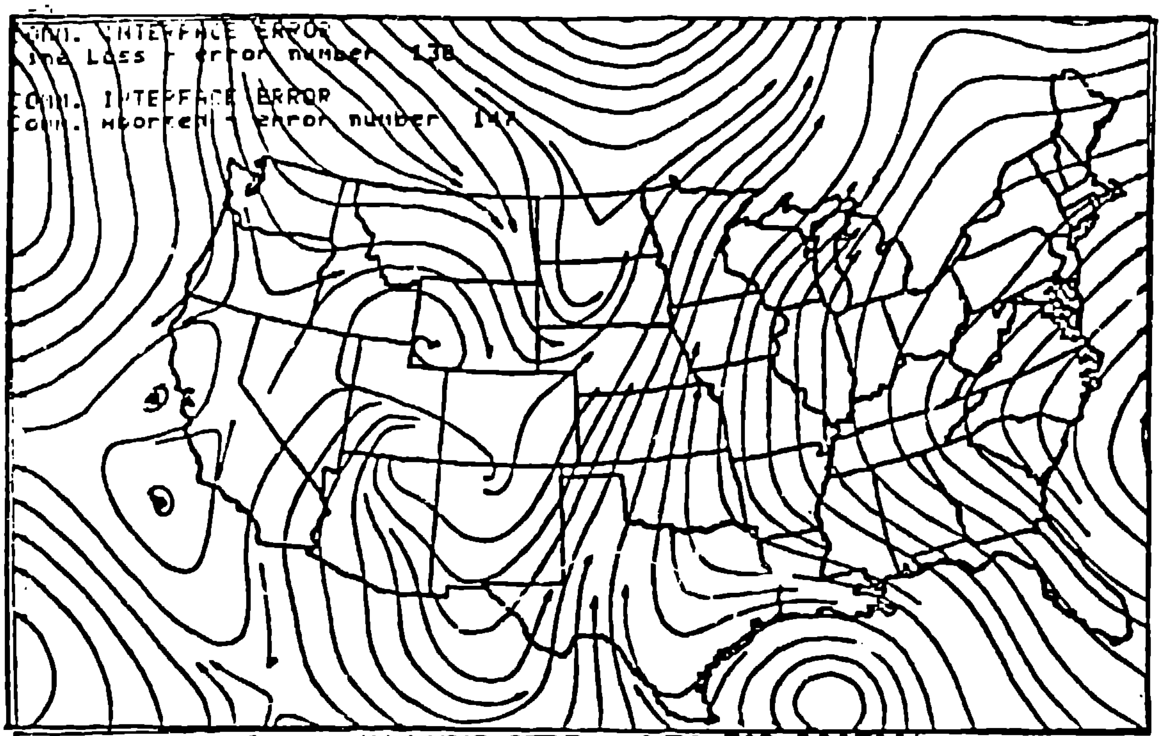
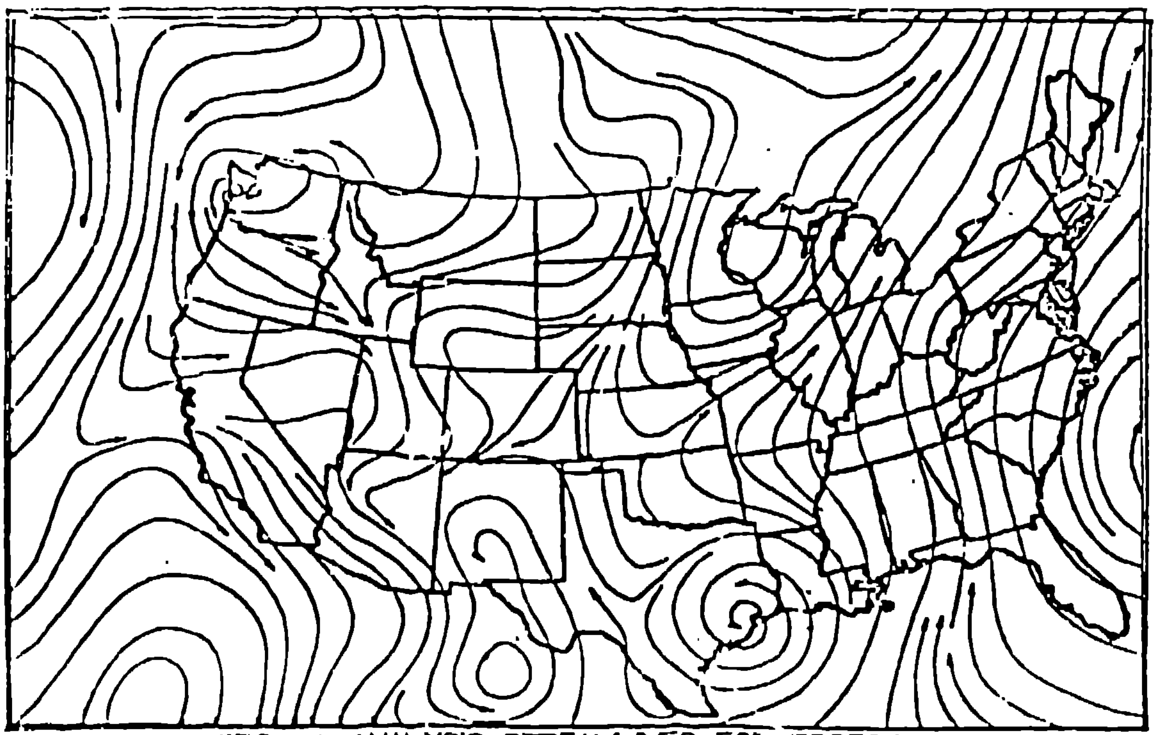
Fig. #4



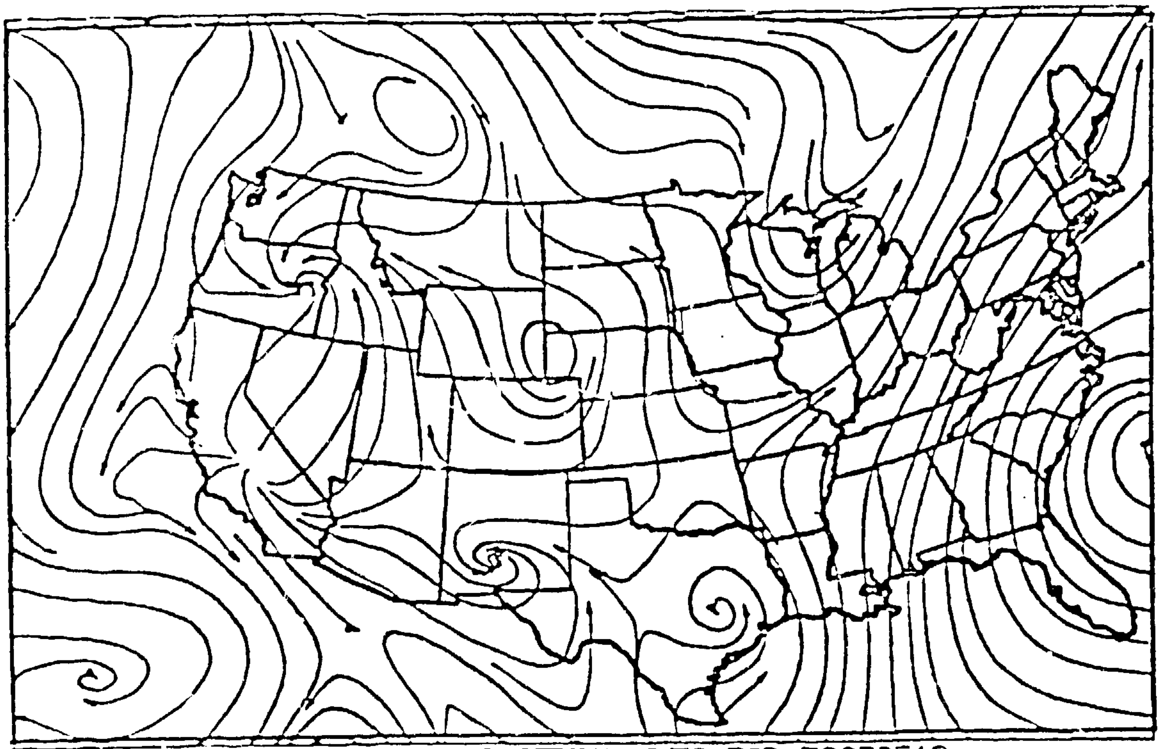
850 mb ANALYSIS STREAMLINES FOR 79072312z

Fig. #5



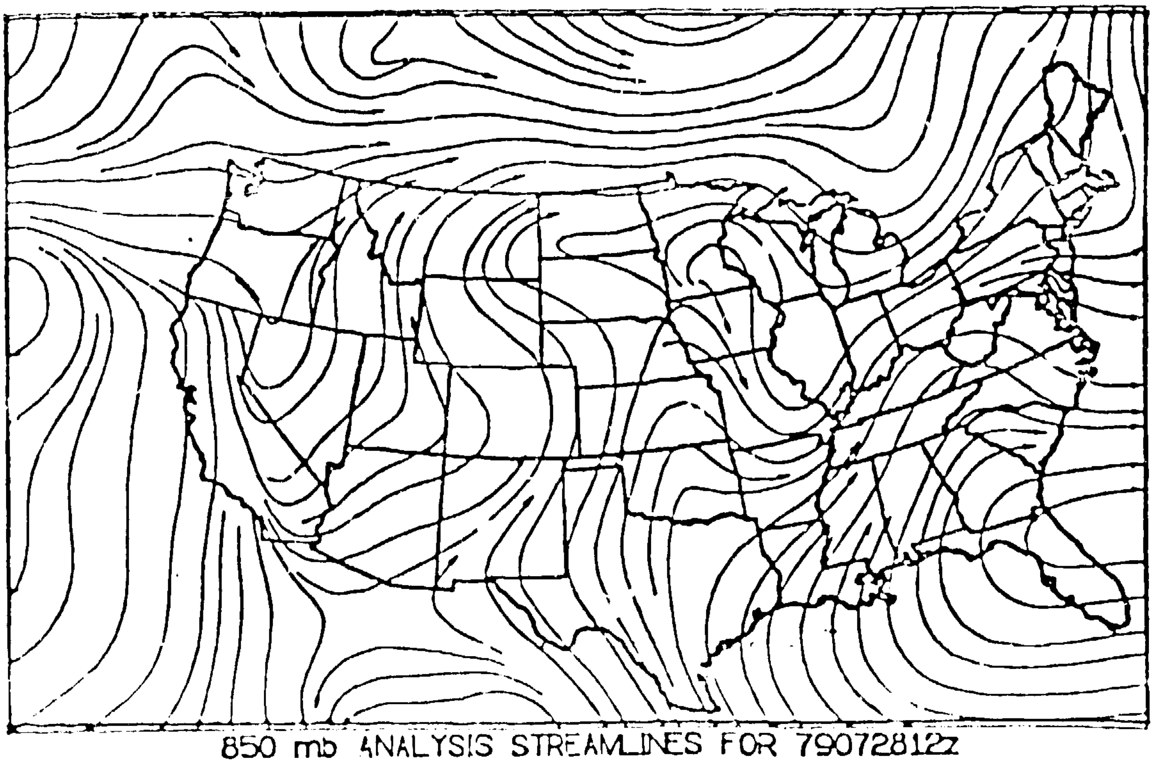
850 mb ANALYSIS STREAMLINES FOR 79072500z

Fig. #6



850 mb ANALYSIS STREAMLINES FOR 79072512z

Fig. #7



850 mb ANALYSIS STREAMLINES FOR 79072812z

Fig. #8

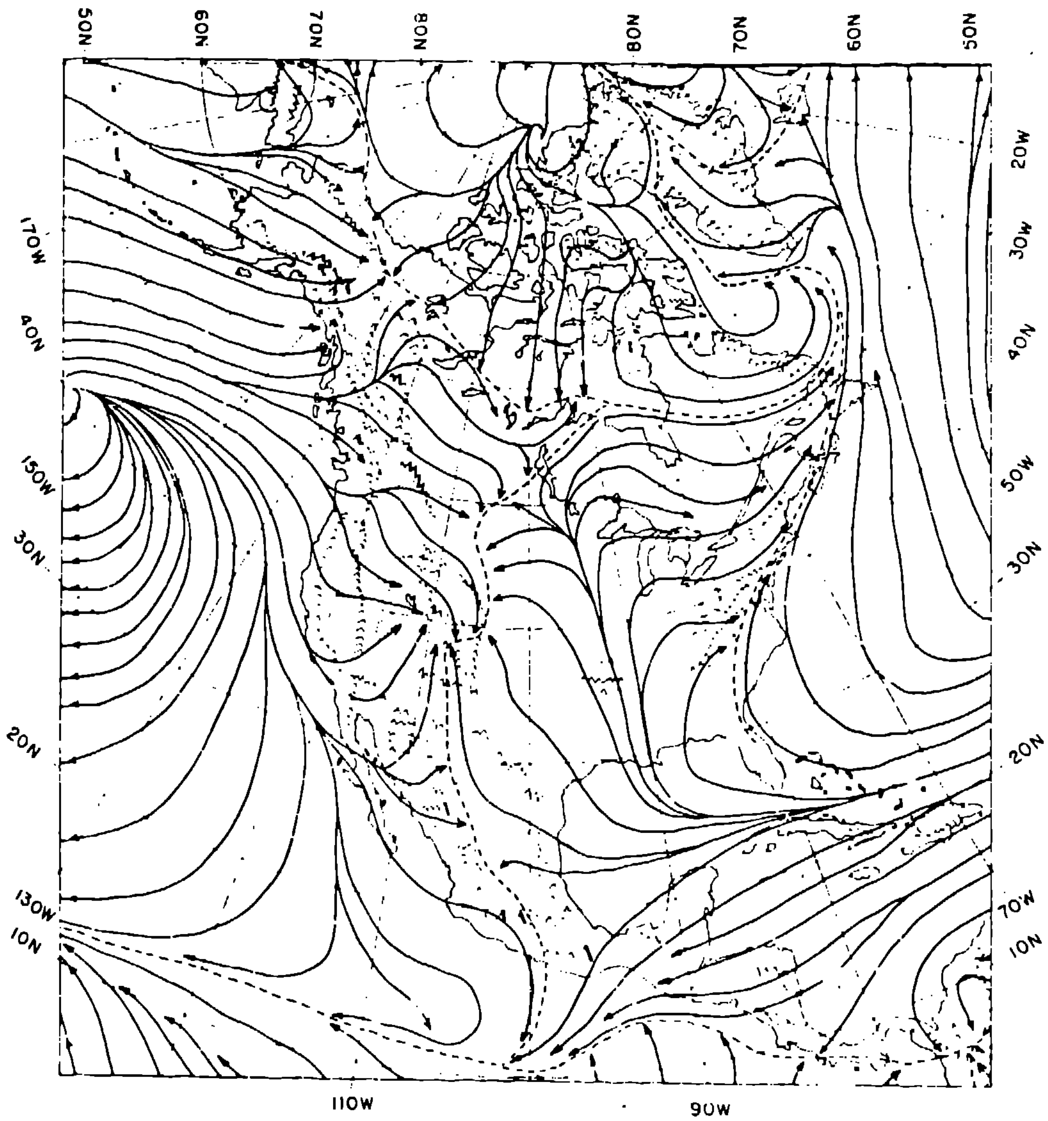


Fig. 9 Resultant surface streamlines for July (after NAVAIR, 1966).

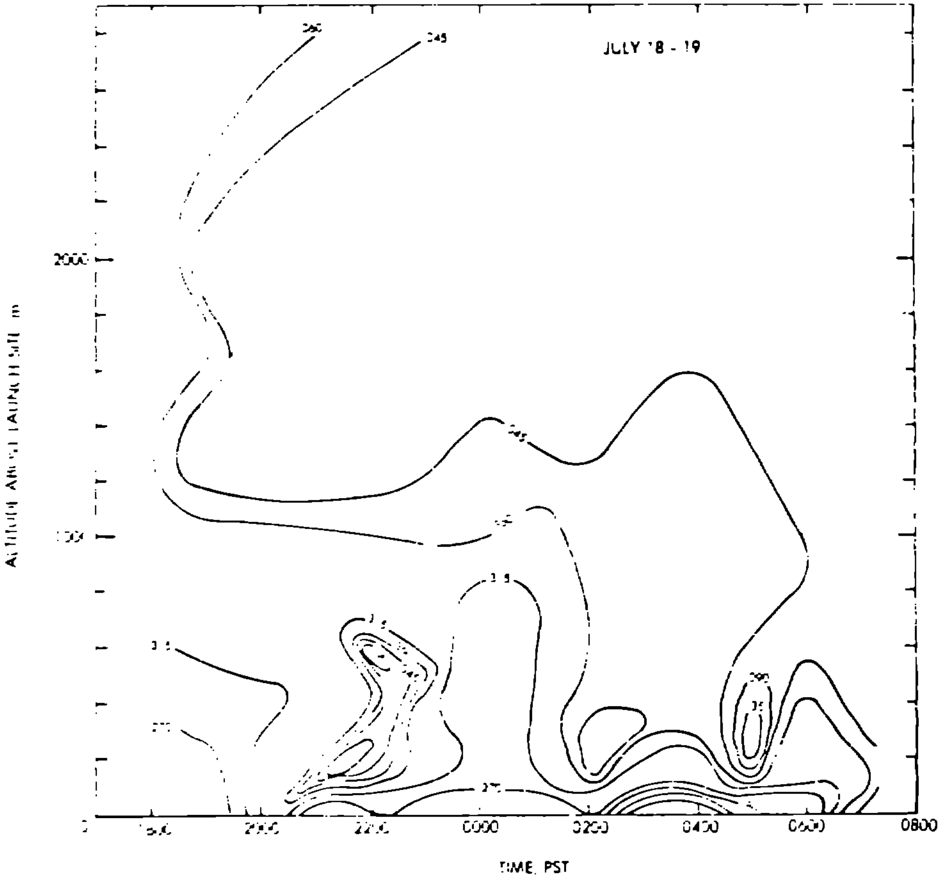


Fig. 10 - Time-Height Cross Section of Wind Direction for July 18-19, 1979

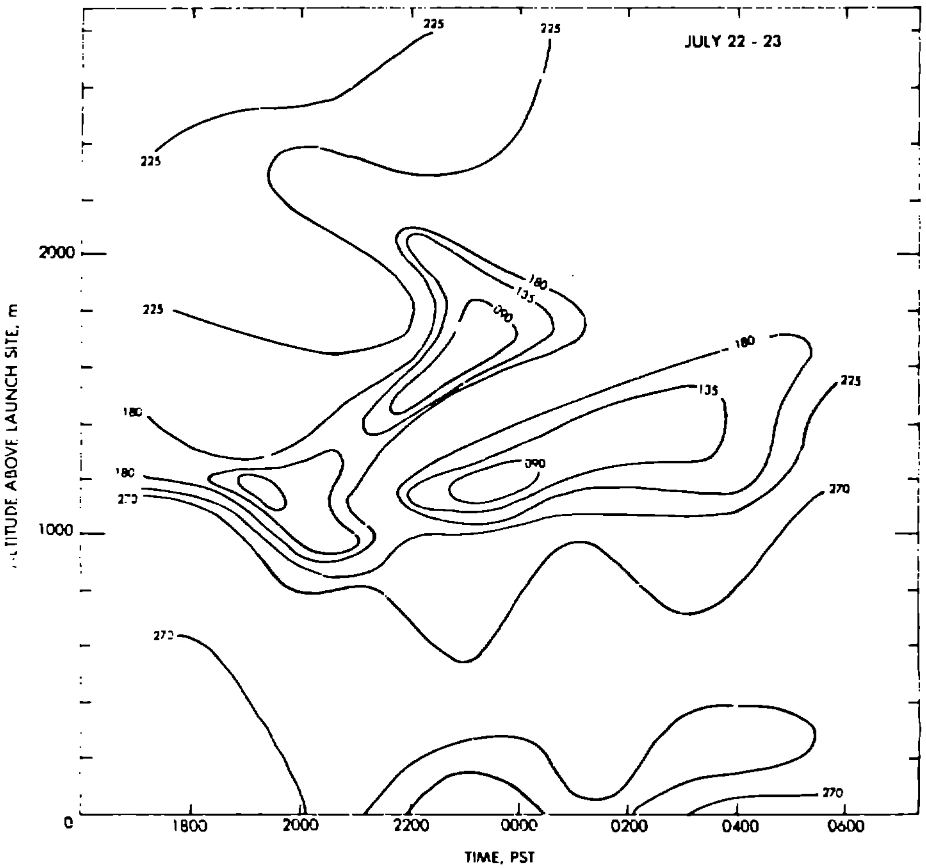


Fig. 11 - Time-Height Cross Section of Wind Direction for July 22-23, 1979

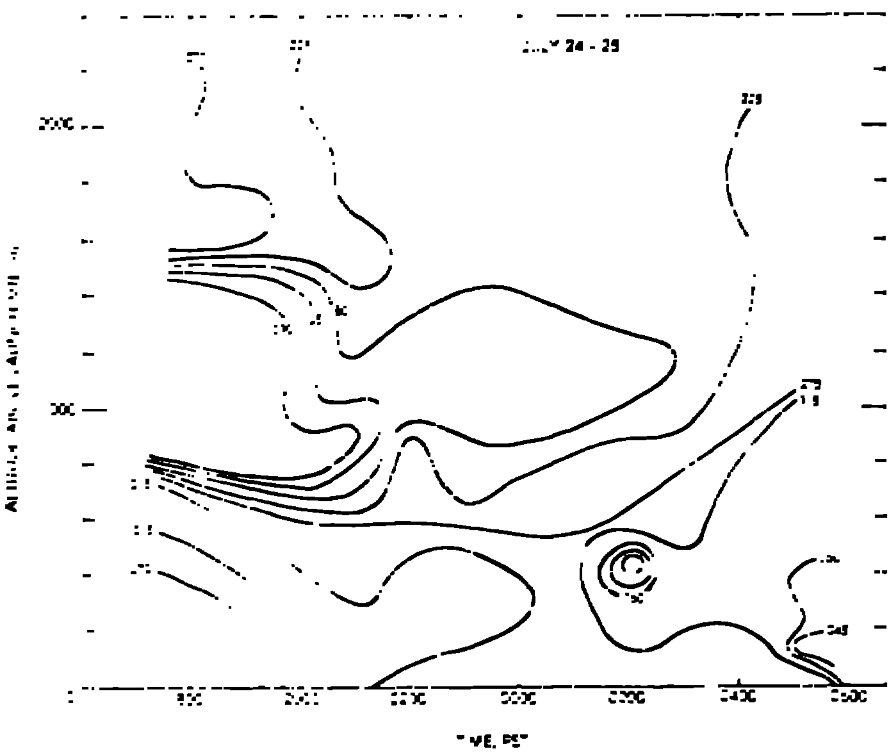


Fig. 12 - Time-Height Cross Section of Wind Direction for July 24-25, 1979

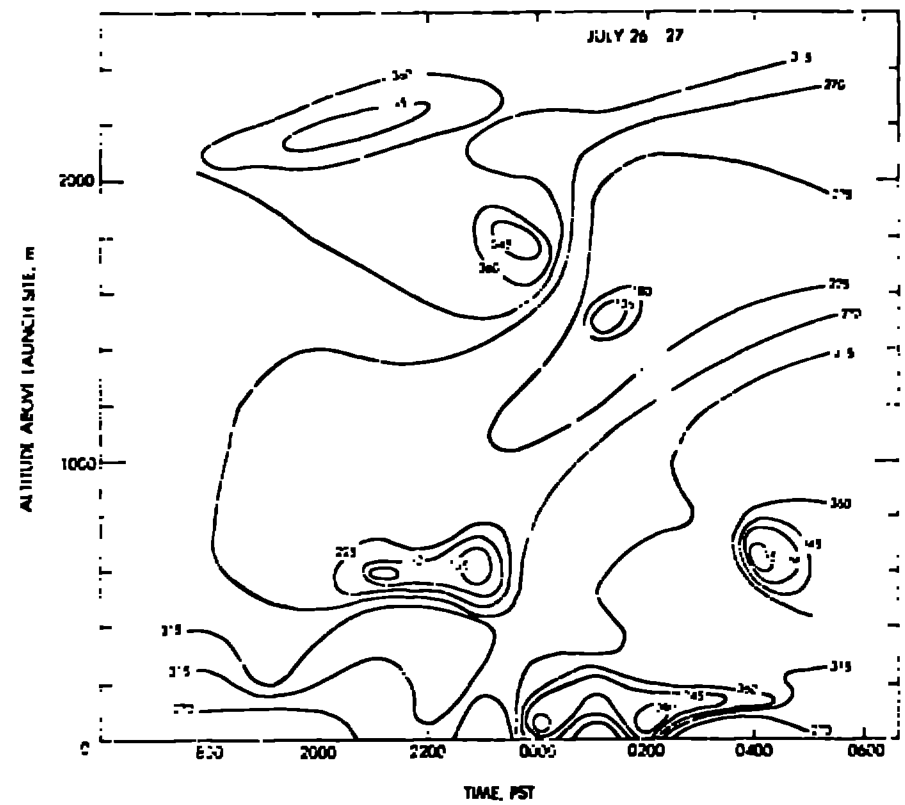


Fig. 13 - Time-Height Cross Section of Wind Direction for July 26-27, 1979

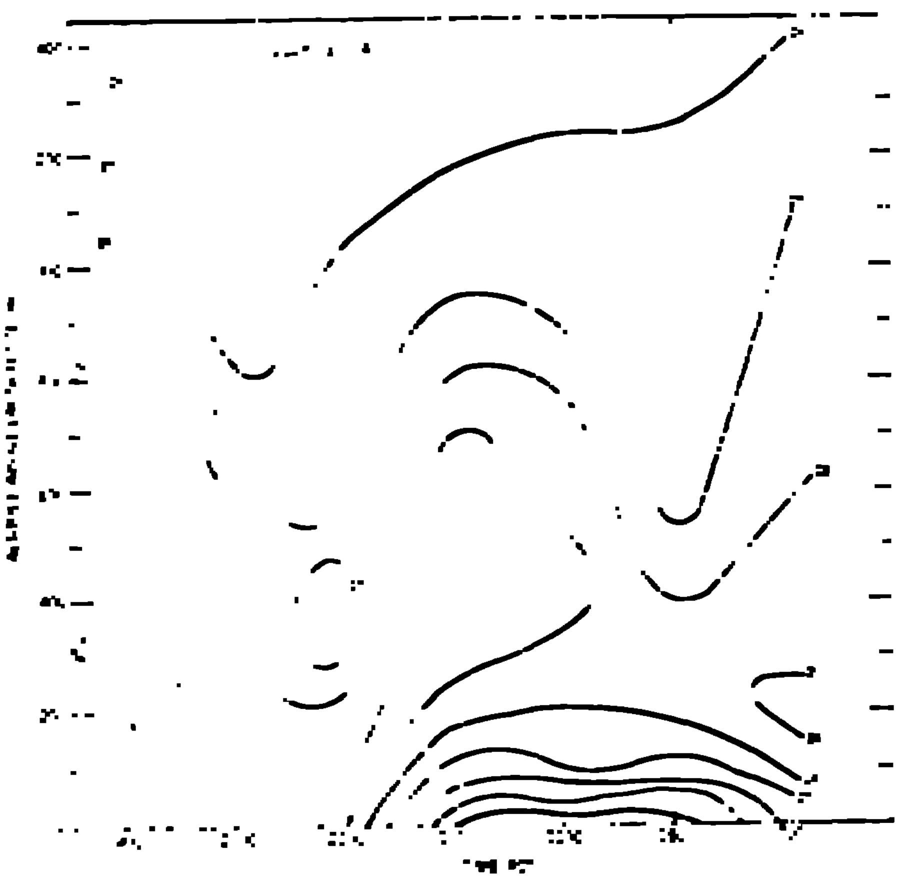


Fig. 1[illegible] - Time-height Cross Section of Temperature for July [illegible], 1979

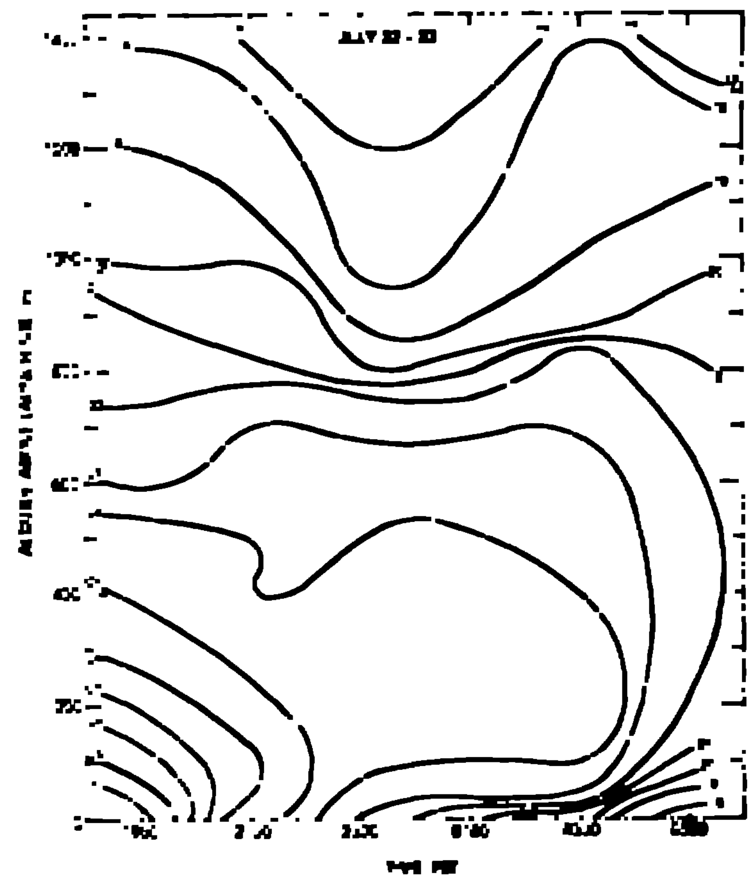


Fig. 15 - Time-height Cross Section of Temperature for July 22-23, 1979

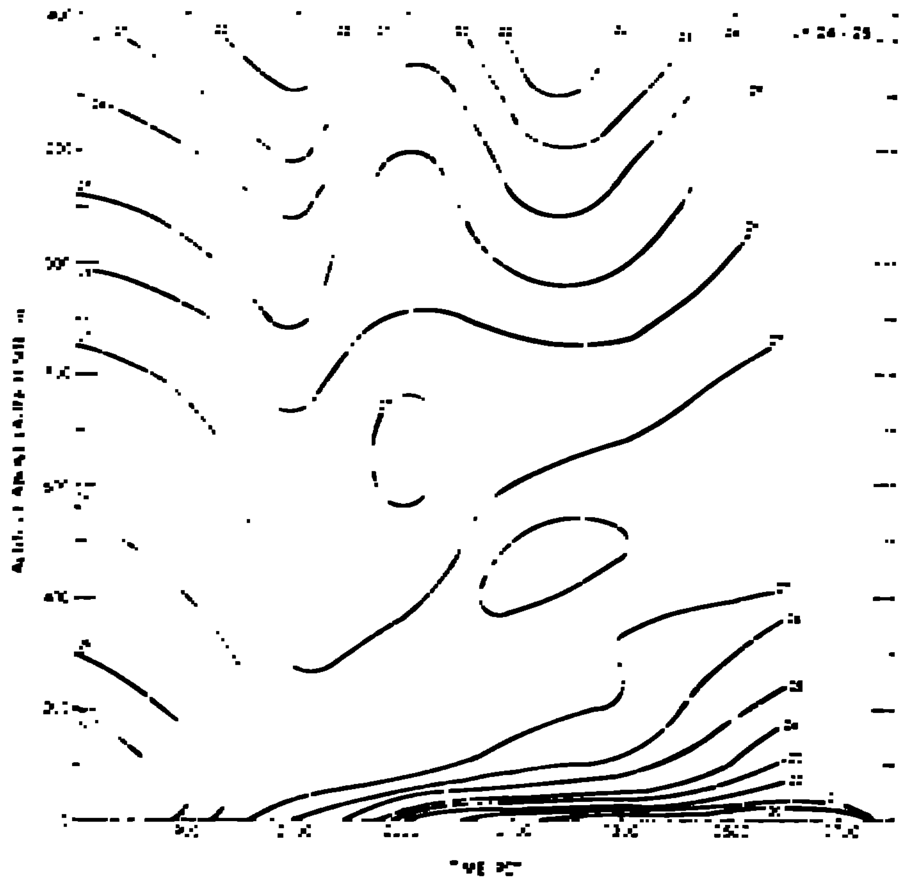


Fig. 16 - Time-Height Cross Section of Temperature for July 24-25, 1979

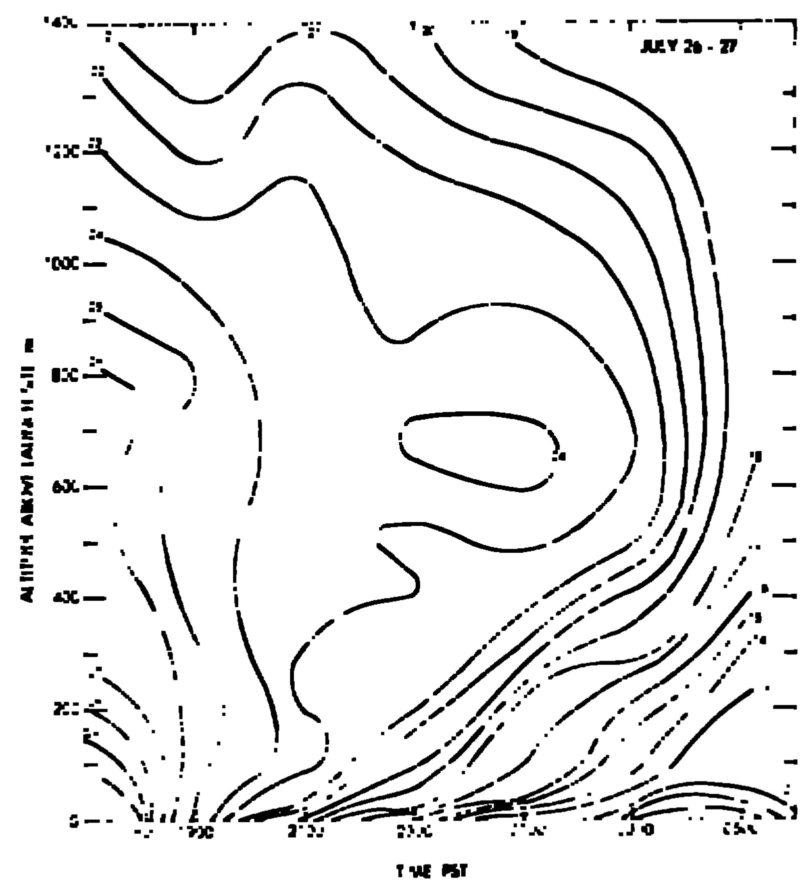


Fig. 17 - Time-Height Cross Section of Temperature for July 26-27, 1979